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'Synthetic Blood': Entangling Politics and Biology

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Abstract
It is increasingly suggested that shortages in the supply chain for human blood could be met by the development of techniques to manufacture human blood *ex vivo*. These techniques fall broadly under the umbrella of synthetic biology. We examine the biopolitical context surrounding the *ex vivo* culture of red blood cells through the linked concepts of alienation, immunity, bio-value and biosecuritization. We engage with diverse meanings of synthetic blood, and questions about how the discourses of biosecurity and privatization of risk are linked to claims that the technology will address unmet needs and promote social justice. Through our discussion we contrast communitarian ideas that culturing red blood cells 'extends the gift' of adult blood donation with understandings of the immunitary logics that underpin the cord-blood economy.

Keywords
alienation, biosecuritization, bio-value, blood economies, cultured red blood cells, gift relations, immune politics, stem cells, synthetic biology

The development of techniques for the culturing of red blood cells, sometimes called synthetic or manufactured red blood cells, is part of a wider emergence of regenerative medicine as an expanding field attracting public and private investment. The manufacturing of red blood cells and their entry into national and international blood

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economies present possibilities for the extension of both government and private capital into the functioning of biological systems; an amplification of both governance over, and economization of, life itself with aims that include both the regeneration of economies (in the broad sense) and bodies (Cooper, 2008; Kent, 2012; Rose, 2007; Waldby and Mitchell, 2006). In this article, we first describe the development of cultured red blood cell technology and situate this within the context of wider efforts to address 'unmet need' within blood economies. Second, we interrogate the political context and framing of these efforts, and examine suggestions that 'synthetic blood' potentially weakens kinship bonds and threatens social solidarity (Weston, 2013). In so doing we hope to contribute to contemporary discussions of 'new biologies' and the continued 'entanglement of politics and biology' (Jamieson, 2016) in the context of synthetic biology.

Recognition of the ways in which politics and biology are 'entangled' implies asking in what ways new blood technologies could transform social relations, political divisions and existing inequalities, and also in what ways the new technologies are shaped by them. For us, key questions concerning cultured red blood cells include: How are 'needs' constructed by the technology within the context of current blood economies? Who might benefit from this technology and how might these benefits be distributed? How do models of immunitary thinking assist us in mapping the biopolitics of cultured red blood cells? We think that the institutional context for the development of cultured red blood cell technology and the distinction between welfarist and non-welfarist immuno-politics is central to situating cultured red blood cells within blood economies. Our focus is on the current investment in this technology in the UK's National Health Service (NHS) Blood and Transplant service, an executive non-departmental public body of the UK's Department of Health. We acknowledge, however, that analysis of the blood economy via simple public vs private or welfarist vs non-welfarist dichotomies is problematic.

In this regard, the work of Italian philosopher Roberto Esposito (2010 [1998]) has been influential in recent discussions of blood and cord-blood economies. Esposito's account of the difference between the political concepts of community (*communitas*) and immunity (*immunitas*) offers an alternative to the binary thinking of shared

public resources vs private individualized markets. In contrast to bioethical assumptions that blood donation construed as a gift creates community, Esposito's view of community stresses the creation of bonds characterized by obligation and moral debt. Immunity, on the contrary, offers protection or release from political obligations to others and in doing so can serve to safeguard the life of the one granted immunity.

Drawing on his ideas, Brown and Williams (2015) analyse the international exchange of units of cord-blood-derived stem cells for transplantation through the lens of an immunitary regime where precise matching requires a network of linked repositories of material and data. They say this 'cosmopolitan internationalization' is central to the cord-blood immunitary bioeconomy (2015: 6) because it releases 'immunized' individuals or specific sub-populations from their obligations to a broader political community. Importantly, this goes beyond notions of blood economies as tied to national welfare-state contexts or public/private distinctions – although both are involved. We return to this later when we discuss the use of cord-blood stem cells for culturing red blood cells, which we see as an extension of this immunitary politics of blood. Thus the term 'immunity', as used here, is primarily a political and not biological signification, though it is applied in the context of health and medicine.

Nonetheless, in view of our discussion of cultured red blood cells, we understand immunitary or immuno-politics to be the mitigation of health or other biological risks to individuals, populations or population subgroups through the application of biopower and/or biosecuritization, specifically the regulation of various boundaries. Biosecuritization can be understood as techniques to secure or isolate bio-value from possible contamination, waste, or other forms of loss. We use the term 'bio-value' here in the sense designated by Waldby, as value that is 'generated wherever the generative and transformative productivity of living entities can be instrumentalized along lines which make them useful for human projects' (2000: 33). We assume that the creation of bio-value entails the application of technical labour or *technē* to living matter. Securitization processes usually entail the separation of the biological material that has been designated as a potential asset or commodity from its original context, that is, the donor body, and the subsequent creation of bio-commodities that move through systems of exchange, sometimes structured as

markets, sometimes not. The terms 'asset' and 'commodity' are not interchangeable. An asset is a resource that has value or can be used to generate value, and at the same time has value as property. A commodity is an object that has been produced for exchange. An asset increases in value as demand increases; a commodity decreases in value as demand increases (law of demand) (Birch and Tyfield, 2013: 302). Human tissues may acquire a price even when the intention is not to trade them as commodities (Hoeyer, 2013). In short, in the context of regenerative medicine, and cultured red blood cells more specifically, immunity refers to securing objects that have biovalue not only from loss but for the exclusive use of the immunized individuals or group. This releases the immunized persons from obligations stemming from sharing risks and resources with the broader community, whether that is construed locally, nationally or globally.

At the centre of our analysis is an attempt to address questions about how the discourses of immunity, biosecurity and privatization of risk are linked to claims that the technology will address unmet needs and promote social justice. We are concerned with both the economic and socio-ethical value of cultured red blood cells while not wishing to conflate them (Birch and Tyfield, 2013); we see these aspects as interlinked. We argue that the introduction of cultured red blood cells into national and global blood economies should be understood as a form of biosecuritization and we ask what forms of immuno-politics are enacted by this introduction.

To begin, we review current sociological understandings of relations within blood economies (exchange systems) and examine claims that culturing red blood cells will revolutionize transfusion medicine. We then discuss contemporary techniques being used to develop 'synthetic blood' or cultured red blood cells from haematopoietic stem cells. This allows us to assess the extent to which cultured red blood cells represent a reconfiguring of relations within blood economies. The metaphor of 'extending the gift' (of blood donation) has been used to describe techniques for cultured red blood cells synthesis.[1] However, this benevolent understanding of synthetic blood production has also been countered by claims that the production of synthetic blood per se threatens to weaken important kinship bonds, create new market-driven flows of circulation and exchange of bio-commodities, further 'capitalisation of nature' itself, and ultimately threaten existing forms of social solidarity and increase

experiences of alienation (Weston, 2013). We address this conflict of interpretations.

Features of Contemporary Blood Economies

Relations between 'donor' and 'recipient' bodies in contemporary blood economies have been widely discussed (Busby et al., 2014). Conventional understandings of these relations in Western economies have drawn on notions of 'gift relations', where voluntary unremunerated blood donation by 'healthy' donors is the model preferred by many policy makers and blood service providers (Titmuss, 1970; WHO, 2014). Such arrangements are seen as contributing to social solidarity and shared values, foregrounding the altruistic motivations of donors to 'give life' to others in need and creating bonds between them. At the same time, the safety of the blood supply is protected through careful screening of potential donors and exclusion of 'risky bodies' where there may be risk of transmitting infection or viral disease: biosecuritization (Kent and Farrell, 2015). Population-wide participation in blood donation is still relatively low; in the United States less than 10% of potential donors actually donate; in the United Kingdom the figure is 3%.[2]

However, more complex dynamics are at play within transfusion science and the global blood economy. There are, for example, other models of blood services: replacement donation, that is, donation by a family member; and paid donation – especially for plasma, alongside industrial processing of plasma and manufacture of blood products (mostly in the US). Socio-cultural values shape these practices: in some countries payment for blood is considered ethically acceptable while in others blood donation from women is discouraged (Kent and Farrell, 2015), particularly in the context of populations affected by thalassaemia (Chattopadhyay, 2006). The exclusion of some groups from becoming blood donors (known as donor deferral), such as men who have sex with men (Berner, 2011; Galarneau, 2010; Hurley, 2009) or migrants (Polonsky et al., 2011) draws on culturally constructed concepts of risk (Strong, 2009) and is an example of the biosecuritization of the blood supply.

Against this background, it has been suggested that the 'production of cultured red blood cells from stem cells holds the promise of revolutionizing transfusion medicine and the existing red blood cell

supply system' (Bouhassira, 2012: 928). This promise of a 'revolution' draws on particular understandings about what is new about the production of cultured red blood cells and resolution of major technical and social issues.

The strategic aims of producing cultured red blood cells at scale are framed in several ways. First, 'synthetic' or 'cultured' blood has been framed as a safer alternative to conventional blood donation. Compared to the risks of transmitting infection via use of donated blood, 'ex vivo production of red blood cells in the laboratory can be rigorously monitored and controlled to eliminate infectious risks' (Shah et al., 2014: 347). Unlike donated blood, cultured red blood cells can be understood as a mechanism of biosecuritization insofar as they supposedly mitigate risk, not just to potential end users, but to the blood supply itself. In this framing, the technical control of cell differentiation, expansion and scale-up are presented as less risky than the screening, processing and distribution of donor blood. This claim merits closer analysis. The potential risks of using donated blood are, in many countries, mediated by screening of donors, protocols for exclusion of those deemed unsuitable to donate, quality systems for the management and processing of donated blood samples, and training for health professionals administering blood-based therapies, together with monitoring of adverse incidents.[3] In Europe, blood donation and blood products are highly regulated (Farrell, 2012). In the United States, the Center for Biologics Evaluation and Research regulates the collection of blood and blood components for use in both transfusion or for the manufacture of pharmaceuticals.[4] Second, proponents of cultured blood manufacturing also argue that current arrangements for the collection and distribution of blood and blood products are inadequate to meet demand, inefficient in reaching those who need it most, risk transmitting disease, and cause additional problems for those with chronic blood disorders due to the proliferation of antigens in response to multiple transfusions. However, this narrative conflicts with practices where target groups for early trials of cultured red blood cells are patients with rare blood groups and inherited blood disorders. Moreover, while publicity frequently emphasizes that red blood cell manufacture could address supply shortages,[5] fewer scientists or clinicians argue that cultured red blood cells could *replace* blood services reliant on donated blood. Thus the claim that cultured red blood cells could represent a viable

alternative to large-scale blood donation remains, for the time being, questionable. Third, according to the United Kingdom's (UK) NHS Blood and Transplant service, cultured red blood cells are targeted towards those with rare blood groups for whom blood is in short supply, and those with blood disorders requiring frequent blood transfusions. Cultured red blood cells could reduce the effects of sensitization and iron loading among these patients.[6] Finally it has been suggested that the costs to the UK national blood services of importing blood products derived from stem cells could be reduced (Williams, 2015). It is important to situate these claims in the context of global blood economies since it has been suggested that research initiatives in the UK are targeting wider shortages.[7]

Globally, demand for blood and blood products is growing and there are unmet needs. Factors determining this demand are (a) demographic; (b) clinical – diagnostic and therapeutic possibilities; (c) institutional or organizational, that is, to do with the infrastructure to deliver effective blood services. A review of World Health Organization data (WHO, 2014) indicates that patterns of donation and use vary. On the supply side, over half of blood donations are in high-income countries, where only 18% of the world's population live. Between 2004 and 2012 blood donations increased by 25%. In 73 countries, over 90% of blood collected is via voluntary unpaid blood donation, but 72 countries collect most blood from family/replacement or paid donors. Most countries (113/156) import plasma-derived products. On the demand side, 'in low-income countries up to 65% of blood transfusions are given to children under 5 years of age: whereas in high-income countries the most frequently transfused group is over 65 years of age, accounting for up to 76% of all transfusions'. Pregnancy-related complications are also a common cause for transfusion in low-income countries (Shah et al., 2014). In wealthy countries, demand for blood products is increasing as demographic change means an ageing population, while declining birth rates suggest there will be fewer donors (Seifried et al., 2011; Shah et al., 2014). Some estimates suggest that in light of this changing demographic profile, 'even in developed countries where the supply is currently adequate the supply of blood will be insufficient by 2050' (Shah et al., 2014: 346). Consequently, securing the future blood supply is a high priority for many countries and national policy development, building appropriate national infrastructure and

national self-sufficiency based on voluntary unpaid donation is being promoted (WHO, 2014).

Clinical practice also shapes demand and the use of blood or plasma products. For example, patients with haemolytic diseases, when regularly transfused, can become sensitized to antigens that are not normally reactive, which creates demand for 'more precise matching' (Bouhassira, 2012). Increased sensitivity can make treatment difficult and requires greater selectivity of the donated blood in order to avoid complications. Incidence of inherited blood disorders such as sickle cell disease (SCD) or thalassaemia varies across countries and population groups.[8] Both these haemoglobin diseases have been 'ethnicized' and racialized (Carter and Dyson, 2011; Dyson, 1998). Sickle cell 'is a disease that has attracted the epithet of being ethnically specific, one that "naturally" but superficially has come to be associated with Black African ancestry' (Carter and Dyson, 2011: 947). Medical knowledge about these genetic diseases has mapped them onto 'ethnic groupings' relying on racist and essentialist assumptions about the link between genetics, ancestry and kinship. In the UK, thalassaemia beta major affects an estimated 1000 people, who require blood transfusion throughout their life. Patients with thalassaemia or SCD are most likely to receive cultured red blood cells during early trials (NHS Blood and Transplant, 2015), though the first human trial in the UK, due to begin in 2019, will be in healthy volunteers.[9]

Causes of failure in the blood supply can relate to shortages of stocks associated with falling donation rates or poor national infrastructure, poor quality management procedures which may lead to contaminated blood products, or poor clinical practices deployed in the administration of blood products or other adverse incidents in patient recipients. Regulatory failure may also lead to problems, as illustrated in the 1980s and 1990s, when blood contaminated with HIV and hepatitis C entered the supply (Archer, 2009; Farrell, 2012; Penrose, 2015). So far we have confined our discussion to adult blood donation, later we will turn to cord-blood banking.

Historical accounts suggest that substitutes for blood are not a new idea. Since the beginning of the 20th century, when understanding of blood group antigens emerged, blood cross-matching was seen as important in developing blood technologies.[10] Blood banks developed in the interwar years as storage methods improved. But the

quest for alternatives to donated blood continued. Weston (2013: 247) suggests that 'the quest for synthetic blood participates in a broader capitalization of nature that promises to domesticate kinship'. Before responding to this, let us first describe the technology in more detail.

Culturing Red Blood Cells – Technology Development

There have been various attempts to develop different types of 'synthetic blood' or blood substitutes. Acellular blood substitutes (sometimes referred to as 'artificial blood') *potentially* have a number of functional advantages over donated blood – they would not require cross-matching or compatibility testing, would be suitable for long-term storage, be able to survive in vivo for several weeks before being excreted, be free of side effects, free of pathogens, and transport and deliver oxygen to the tissues (Squires, 2002). Since the 1970s, attempts to produce alternatives to haemoglobin found in red blood cells to take up, transport and deliver oxygen to tissues have presented technical challenges. South Africa and Russia approved products such as Hemopure, a stabilized bovine haemoglobin[11] for clinical use (Chang, 2012; Ferguson et al., 2008; King, 2013).[12] In the USA, Northfield Laboratories developed and trialled Polyheme, a product derived from modified human haemoglobin for use in resuscitating trauma patients but ceased production in 2009 when marketing authorization was refused (Apte, 2008; Kipnis et al., 2010). Substitutes using perflourocarbons, a synthetic compound in solution and oxygen carrier, have also been controversial but considered potentially useful (Barbosa et al., 2009; Spahn, 1999). Some have suggested that sugar beets could be used in producing a blood substitute.[13]

The need to resuscitate wounded persons in war conflict zones has been a key driver for some of these initiatives, but more recently techniques to develop 'synthetic blood' have centred on the culturing of red blood cells for broader application. Worldwide, a number of research teams (Anstee et al., 2012; Douay, 2012; Kim, 2014; Nakamura, 2008) have explored producing cultured red blood cells for transfusion, requiring a high level of investment for laboratory studies, scale-up and clinical trials (Migliaccio et al., 2012). Teams use different starting materials and methods. The Bristol Blood and Transplant Research Unit[14] group uses haematopoietic stem cells

obtained from adult donor blood and umbilical cord blood. Our focus in this article is on these two sources. We do not discuss the use of human embryonic stem cells or induced pluripotent stem cells as used by the Bloodpharma project in Edinburgh, UK, or the challenges of scale-up or translation (King, 2013; Lapillone et al., 2010; Mazurier and Douay, 2013; Mittra et al., 2014; Mountford et al., 2010; Mountford and Turner, 2011; Ramesh and Guhathakurta, 2013; Trakarnsanga, 2014).

Breaking Bonds, Alienation, Biosecuritization and Immuno-politics

Given this institutional and technological context, how best to understand where cultured red blood cells fit into the contemporary politics of blood economies? In Titmuss's (1970) influential model of the gift relationship, through which blood donation is most often framed, *voluntary unpaid* blood donation is tied to notions of citizenship and social solidarity, underpinning certain functions of the welfare state in Western economies. Commodity-based systems (as characterized by blood services in the US), by contrast, represent a market-based model of exchange distinct from the welfarist example (Migliaccio et al., 2012). But contemporary blood economies are almost always characterized by the *coexistence* of gift and commodity or welfarist and market-based forms of exchange (Waldby and Mitchell, 2006). In the UK, for example, while adult blood donation is unremunerated and national blood services are not for profit, an internal market based on 'cost recovery' operates within the NHS for blood products and participates in the broader technoscientific enterprise and political economy through the exchange of materials, information, equipment and knowhow. Simultaneously, the NHS imports a wide range of commercially produced plasma-derived products. Modern transfusion services, banking, and synthesis techniques entail compartmentalization and commodification as essential aspects of the biosecuritization necessary for the functioning of blood economies. Public and private sectors overlap here and blood flows between them, the same holds for cultured red blood cells, and importantly the source materials for such cells. For this reason, parsing the politics of cultured red blood cells through a neat public/private distinction is not adequate.

Weston's (2013) argument that the 'quest for synthetic blood' is a continuation and development of the 'alienation' inherent in other forms of blood storage and transfusion, and more broadly in 'biosecuritization', is the most thorough attempt to analyse the social implications of synthetic blood production and entrance into blood economies. She contends that the drive towards the development of synthetic blood and its introduction into the blood economy restructures social relations: 'taming kinship' by dissolving direct relations between blood donors and recipients, undermining 'naturalized' familial and blood ties. The appeal of blood synthesis, she argues, stems from 'an attempt to evade or renegotiate the imperatives of [. . .] other' types of synthetic kinship structures. Her concern is for certain forms of 'kinship' that were previously facilitated by regimes of blood transfusion gift economy – particularly vein-to-vein transfusion. This argument, we think, functions more as a critique of biosecuritization than of cultured or synthetic blood per se. We understand 'kinship' here to mean not just familial ties but other forms of community and social solidarity. Tracing the purported alienation and abstraction of blood transfusion practices through the establishment of national blood banks she observes how blood shortages are construed as deficits in bank stocks, despite the plentiful blood in the veins of the population. For example, donor recruitment drives draw on a discourse of face-to-face relations between donors and recipients and obscure the circumstances of the production and marketing of blood products within capitalist economies. Moreover, while the discourse of 'the gift of life' permeates calls for donation, commodification of blood is, at the same time, a primary aim in the dynamics of all contemporary blood economies, including efforts to develop scalable cultured red blood cells.

We suggest that her critique of synthetic blood as a form of alienation deploys the concept of alienation in a manner that is not appropriate to the question of cultured red blood cells per se. Weston's focus on concepts of alienation and commodification in the production of biocapital deploys Marx's concept of alienated labour: 'alienation can be devastating, creating what Marx called a "realm of estrangement" that separates people from their life activity as well as one another' (Weston, 2013: 251). But does this category of alienation apply as cleanly to the manufacturing of red

blood cells and the introduction of synthetic blood into blood economies as Weston suggests?

Weston is correct to say that the concept of alienated labour applies to all wage labour within capitalist modes of production. Alienation, in this context, refers to the separation of a person from *relations* and *functions* that are proper to the person qua human being and necessary to her flourishing. Alienation is thus experienced as both deprivation and lack. Moreover, it refers to a phenomenology (i.e. subjective experience) and a set of objective conditions pertaining to what a human properly is and should be able to do. In Weston's account, the introduction of cultured red blood cells threatens to alienate subjects from kinship relations that are constitutive of some dimension of their personhood. Her emphasis on compartmentalization suggests that her focus is on a *substance* or material base as the object of alienation rather than a set of functions and relations. The blood ceases to be a part of the embodied person, and subsequently part of a symbolic web of kinship relations, and instead becomes 'biocapital' (living matter that is used to generate income or value). Weston's concern is that kinship relations are weakened by the potential diminishing of the symbolic value of blood relations, including transfusions, within certain populations: 'taming kinship relations through the commodification of blood may not have universal appeal, especially for groups whose ethnicity and/or nationality is bound up with the valorisation of family' (Weston, 2013: 246). Two discourses seem to be combined here: a concern for the weakening of certain types of kinship relations that may underpin national or other communitarian imaginaries, and a concern about transformation into assets and/or commodification of blood and blood products within biocapital market economies, where biosecuritization provides the impetus for the further development and growth of these processes.

Pertaining to the first discourse, to the (questionable, considering how little of the population participates) degree that blood gift economies are constitutive, at least in part, of kinship relations linked to ethnic and national communities, it is not clear that this is in any way normative. As we described earlier, these blood gift economies tend to be exclusive. Moreover, communities that privilege '*sang*' over other forms of civic solidarity also tend to be exclusive, often to the extent of being oppressive, and in their refusal of other obligations or

responsibilities towards persons outside of the community of blood and soil. It is also not clear that there is any reason to privilege kinship relations at ethnic or national level. Weston is admittedly ambiguous on this point, both alluding to the presumed importance as well as perhaps authenticity of these types of relation, while acknowledging their potential for becoming exclusionary. She acknowledges that the abstraction of blood products from their source (the direct donor or the source material for cultured red blood cells) can undermine objectionable obstacles, for example, racism based on a fetishization of blood ties to donation and transfusion: 'transfer of blood ends up generating a kind of race/class solidarity, figured in kinship terms, that no amount of talk or union organising had managed to produce' (Weston, 2013: 248).

In this example, the sacrifice across fetishized bloodlines (race) has the symbolic force of generating new forms of solidarity, for example, class over race. There is nonetheless an important ambiguity at play since the symbolic value of the sacrifice – in this instance giving blood – is amplified by precisely the fetishization of blood that the example is meant to downplay or overcome. A more effective line of approach might have been to focus on the more general link between sacrifice and solidarity in the *generation* of civic solidarities. We use the term 'generation' here because there also seems to be present in Weston's analysis an assumption of the *natural* givenness of certain kinship relations and not others; hence the distinction between natural and synthetic kinship, which is maintained throughout her paper. Weston does acknowledge that even 'the most naturalised of kinship ties must be synthesised in some sense, insofar as they are meaningfully constituted through culturally and historically located practices' (Weston, 2013: 245).

The 'bleed for England' blood donation campaign launched by the NHS Blood and Transplant service, in parallel with the 2015 Rugby World Cup (hosted in England), provides a good example of the ambiguity in these overlapping concepts of kinship or solidarity. The campaign implored English people to make a sacrifice – bleed – in the form of blood donation for the good of the nation. The ambiguity lies in this case not on the side of the act of blood donation but of the community in question: England. Is it an exclusive ethno-national community or an inclusive civic community? Imploring persons to

give blood for the sake of an exclusive ethno-national community in order to reaffirm the fetishized bonds of blood and soil is not, normatively speaking, the same as imploring them to give blood to generate bonds of civic solidarity within more inclusive forms of liberal or republican community.

The further concern for commodification of the body, its parts and processes is also subject to a conflation, this time with forms of alienation and compartmentalization. The conceptual slippage vis-à-vis alienation lies in confusing alienation from a substance with alienation from a function or relation. In the argument that all compartmentalization of the body into mechanical parts and synthesis of blood products involves alienation, sits the presupposition of the body as an organic whole grounded in a substance, rather than the body as a set of functions that can be variously performed, not only often in interchangeable ways but also by interchangeable parts. There are not good reasons to say that the body divided into parts is *by definition* alienated; to do so implies an unproblematic notion of bodily integrity which has been challenged in discussions of organ transplantation and cell technologies (Hoeyer, 2013; Sharp, 2013; Shildrick, 2010). By contrast, a body commodified in terms of parts (e.g. organs) or functions (e.g. units of labour) exchangeable within a market is by definition alienated. That the whole analysable into parts functions as a whole in relation to its environment is not nullified by the division, but only by some kind of operation wherein the body part or function is transformed into a commodity or asset. Nor does the aim of substitution of matter or parts presume the functional independence or self-containedness of those parts, only their materiality and interchangeability within constraints. Compartmentalization and substitution do not rule out relatedness as Weston argues (p247), but rather rule out material essentialism about the embodied human.

In our view, alienation may derive from the transformation into assets or commodification of bodily parts and processes, not from the compartmentalization itself. Neither the weakening of familial or ethno-national kinship relations, nor the material compartmentalization of the body *necessarily* entail the alienation that Weston seems to argue is inherent to the synthesis of red blood cells and their entry into blood economies. Rather, cultured red blood cells are not a form of alienation from the embodied person unless they

become a condition for denying the proper functioning of the person. For example, a situation wherein donated or even purchased blood or blood derivatives are commodified in a blood economy that some citizens do not have access to or have access to only by way of some form of diminishment, such as working extra hours and losing family time to pay for blood products synthesized from donated materials. But the alienation here lies in the social relations not in the intrinsic relations between the embodied citizen and the cultured red blood cells. Thus we think that the commodification of bio-objects and derivatives such as synthetic blood cultured from stem cells can occur within institutional contexts that are not alienated.

Institutions like NHS Blood and Transplant aim to mitigate the possibilities of these types of alienation within a specified territory and are central to the UK effort to manufacture cultured red blood cells at scale and to distribute them. Consequently, any normative analysis of cultured red blood cells must be parsed through an understanding of varying institutional contexts. Though the public–private distinction is not decisive, a distinction must nonetheless be made between welfarist and non-welfarist biopolitics, the former oriented towards maximizing health outcomes and well-being in an equitable fashion across a relevant population, and hence mitigating risk of alienation. Both institutional contexts entail commodification qua production for exchange, but the nature and aim of this commodification is salient. Thus, the pivotal consideration is the institutional context for the synthesis and consequent commodification of cultured red blood cells, not the distinction between natural and synthetic blood or biosecuritized vs authentic transfusions. This institutional context and commodification of cultured red blood cells can be analysed via the concepts of biosecuritization and immunity. Hence it remains salient to ask if biosecuritization necessarily entails a 'capitalization' of the body and a further 'capitalization of nature' that 'promises to domesticate kinship'? And, if so, does this in some way inhibit, limit or degrade relations of solidarity regardless of the institutional context in which it occurs? To address this question in the context of cultured red blood cells, we focus on the institutional contexts of peripheral and cord blood *as stem cell sources* for manufacturing cultured red blood cells.

Situating Cultured Red Blood Cells beyond Welfarist vs Non-welfarist Binary Distinctions: Cosmopolitan Immuno-politics

Stem cells obtained from adult peripheral blood or cord blood can be used to produce cultured red blood cells. Both are collected by NHS Blood and Transplant and the Bristol Blood and Transplant Research Unit. We think that the normative question of biosecuritization, in the context of the potential transformation of blood economies by the development of cultured red blood cells, is closely related to the political context of the source stem cells. Moreover, the debate surrounding cord-blood banking is a helpful heuristic for understanding issues that could arise in relation to the further development and eventual deployment of cultured red blood cell technology. Brown and Williams (2015) and Brown et al. (2011) have used the language of immunity and immuno-politics (borrowed from Esposito) to describe the political dimensions of cord-blood cell banking. Due to the constant intermingling of public and private in the blood economy, they call into question the relevance of the public–private distinction to the political evaluation of cord-blood banking practices. We will follow their lead here but try to maintain the relevance of what we have called the welfarist–non-welfarist distinction, acknowledging the frequent mixing of public and private in welfarist institutional set-ups. Immuno-politics in this context entails a focus on what borders of inclusion and exclusion are drawn in the production and clinical use of cultured red blood cells per se, but more specifically the manner of their institutional introduction into blood economies. This refers to the original juridical sense of the terms *immunitas* and *communitas* that we introduced in the beginning, but the political significance of immunity increasingly refers to how biological materiality appears as constitutive of political boundaries of inclusion and exclusion. There is an important distinction between the privatization of biological risk and the increased securitization of cosmopolitan welfarist politics, that is, public health management systems that do not deploy or operate under binary, for example nationalized or racialized, self vs non-self immuno-politics. Within the context of welfarist immuno-politics, biosecuritization can be a form of immunizing a porous and immunologically diverse community against dangers and risk, not against those simply conceived

biopolitically as others in ethnic, national or economic terms (or some combination). Moreover, it is the privatization of risk carried out in ways that undermine the functioning of welfarist institutions that creates the risk of a normatively problematic immuno-politics, not a natural vs. synthetic distinction. The threat of a capitalization of nature should be seen through this lens and not through a problematic natural/synthetic distinction.

In view of this, we think that there is a politically salient distinction between different cell sources for cultured red blood cell technology, specifically haematopoietic stem cells from (a) donated peripheral blood (from adults) and (b) cord blood. As we have seen, the former mobilizes discourses of community and solidarity in a conventional manner. The use of adult donor blood samples that might otherwise be 'wasted' to produce cultured red blood cells is construed as 'extending the gift' of donated blood. By describing cultured red blood cells as a method for 'extending the gift', the discourse of face-to-face relations and welfarist public health institutions are mobilized to revalidate donation practices and resist the view that the technology can substitute blood donation. Claims that a universal product could address shortages and niche needs within the global blood economy foreground inclusivity and open access, construct particular notions of 'unmet need' but also risk ignoring the political realities of social inequality and difference.

By contrast, the use of stem cells from donated cord blood must be understood within a very different institutional context. Cord blood may be regarded as 'on the borderlands between community and immunity' (Brown and Williams, 2015) a bio-object that straddles both the public–private and welfarist–non-welfarist divide within blood economies (Martin et al., 2008). Cord-blood banking has a history based on the successful use of stem cells from cord blood for transplantation, as an alternative to bone marrow transplants. Harvesting of cord blood for private banking is controversial among clinical, policy and academic communities. There is concern that procurement denies the baby important resources and interrupts the clinical management of labour; second, in contrast to public banks, which rely on altruistic donation, private, commercial cord-blood banks encourage a kind of hoarding, a 'miserly' tendency to save for an uncertain future (Fannin, 2013). Hoarding is thus an integral part of, or at least not in contradistinction to the privatization of risk

and could simply be understood as the transformation into stockpiled assets. So while public cord-blood banks (like banking of adult donor blood) rely on a welfarist ethical imperative to mitigate population-wide health risks through altruistic allogeneic donation and public risk-sharing institutions, private cord bloods mobilize a drive to stockpile assets (withdraw from circulation) and alter the traditional dynamics of welfarist risk-sharing by encouraging individuals to essentially insure *themselves* or their families against potential future health risks. This privatized and individualized form of biosecuritization enacts a very different form of immuno-politics than the public welfarist version. Rather than seeking to secure an, at least potentially, diverse political community against health-risk, the privatization of biosecuritization enacts a boundary of exclusion around the family or other privately insured unit, immunizing or releasing the privately insured unit from obligation or debt to welfarist risk-sharing institutions. This is regardless of the fact that in the case of private cord-blood banking the private investment is speculative and relies on cord blood being exploited in the future, which may depend upon public research investment. Thus, privatization of risk undermines the risk-pooling mechanisms of welfare-statist biopolitics, while at the same time involving those institutions as essential parts of the cord-blood economy and, in particular, the part most likely to be instrumental in the future realization of the present investment (the banking of the cord blood).

Thus, while we agree with Brown et al. that the cord-blood economy undermines any binary distinction between public and private cord-blood banking and that 'whether private or public, such banks are immunitary ventures, stockpiles of immunity' (Brown et al., 2011: 1116), we maintain the importance of a welfarist–non-welfarist distinction, all the while acknowledging that both individual-private and public welfarist models of the cord-blood economy remain 'immunitary ventures'. There is no contradiction, then, in acknowledging with Brown et al. that public cord-blood banking can and often does function according to similar exclusionary immuno-politics on a global scale. In this account, cord-blood banks were set up to address inequalities in bone marrow transplantation and the dominance of White Caucasian donors and under-representation of certain 'ethnic groups'. Cord-blood banks target populations of under-represented groups who also have higher

incidences of haemoglobinopathies and lower stem cell counts. Paradoxically, though set up to address issues of social inequality and justice, cord-blood banks appear to reproduce those inequalities. In the US, despite attempts to enrol African American sickle cell families in stem cell collection, few patients from these families receive transplantations due to underlying 'ethnoracial dynamics' (Benjamin, 2013:115). In tracing the flows of cord blood globally, Brown and Williams suggest that 'cosmopolitan internationalization is central to the underlying rationale and purpose behind the establishment of the [cord-blood] immunitary bioeconomy' (2015: 6) and that cord-blood banking 'subverts both the moral economies of the gift and the political economies of the market' (2015: 11) through an immunitary regime which reconfigures colonialism by deploying the language of 'race' and 'ethnicity', and international registries that construct or 'reassemble a globally distributed diasporic immunity' (2015: 8). Biological immunity is politically drawn through the circulation of cord-blood stem cells which are produced from women's bodies.

Subsequently, we agree that any attempt to apply the binary public vs private or welfarist vs non-welfarist distinction to the downstream synthesis of cultured red blood cells from cord-blood harvested stem cells would likewise run into the same issues that Brown et al. point to in the practice of cord-blood banking itself. The issues pertaining to the institutional and political context of the source materials of cultured red blood cells will likewise apply to the cultured red blood cells. However, beyond the issue of source materials and the immuno-political regimes currently associated with them, we can ask if cultured red blood cells, within a more general institutional context fall within the logic of 'cosmopolitian internationalism' that Brown et al. attach to cord-blood banking? By targeting populations with rare blood groups and those with inherited blood disorders the construction of these 'niche markets' for cultured red blood cells (which may potentially include export across national boundaries) pulls away from the universalizing discourse which heralds 'synthetic blood' as a solution to global blood shortages. Rather, the rationale for culturing red blood cells conceived of as a method for facilitating more 'precise matching' (Bouhassira, 2012) draws on an immunitary logic of self/non-self (better matched blood groups) while at the same time constructing racialized global or cosmopolitan networks of immunity.

We can summarize how we understand the relation between the institutional context of cultured red blood cells and the 'cosmopolitan internationalist' model of the 'immunitary bioeconomy' as theorized by Brown and Williams: the analysis of cord-blood banking brings into question the binary public vs. private or welfarist vs. non-welfarist distinction or models of immuno-politics, in its place Brown and Williams (2015) and Brown et al. (2011) develop the notion of a cosmopolitan internationalist immune politics, which involves both public institutions and the privatization of risk. By extension, this is relevant to the discussion concerning the immuno-politics of cultured red blood cells derived from umbilical cord blood. So the analysis and evaluation of the immuno-political context of cultured red blood cells, that is, production and scale-up within the institutional context of NHS Blood and Transplant, relates to the source materials. A discourse of referring to the culturing of red blood cells as 'extending the gift' signals an intended extension of traditional nation-state-based welfarist discourses surrounding blood donation, and production of blood products for use within the NHS. This intended extension of the welfarist discourse of traditional blood donation is more viable when the source materials are adult stem cells, procured via traditional avenues of donation. The use of umbilical cord-blood stem cells (even where they are donated to public banks), by contrast, situates cultured red blood cells production in the immuno-political context of cord-blood banking described above. If the institutional context of cord-blood banking constructs a network of racialized bodies and identities based on categorizations of immunity (blood grouping and matching), as Brown and Williams argue, then, similarly, by drawing on a notion of 'more precise matching' for those with haemoglobinopathies such as sickle cell disease and thalassaemia and the construction of 'niche markets' for cultured red blood cells to meet rare needs in the international market, cultured red blood cells technology risks reproducing exclusionary 'cosmopolitan internationalist' immuno-politics. Simply put, cultured red blood cells are not biopolitical or immune-political game changers but situate themselves within existing institutional and political orders depending both on source material and intended use and recipients.

Conclusions

The manufacturing scale-up of cultured red blood cells depends on a supply of allogeneic cord blood which, in the first instance, will be sourced from NHS Blood and Transplant's public cord banks, and adult blood donations. The role of NHS Blood and Transplant is crucial as a site for the production of cultured red blood cells but also produces specific understandings of unmet need (Williams, 2015). While boundaries between public donation and benefit, and generation of value are intertwined or entangled, institutionally NHS Blood and Transplant remains within the frame of welfarist biopolitics. As a key partner in the UK research effort they lead and support the scientific research, lead on the safety and clinical testing of the cells, and on developing the manufacturing process to meet regulatory requirements and to produce cultured red blood cells at scale. So far it is unclear what the business model for future translation and diffusion of the technology might be but evidently this state-funded institution has an infrastructure and expertise for producing and distributing this product. Production of cultured red blood cells at scale for transfusion and potential distribution via NHS Blood and Transplant may be seen as an extension of the biopolitics of the welfarist blood gift economy – via the 'extending the gift' trope.

We situate the current large investments by the UK's NHS in the development and scale-up of this technology of the culturing (manufacturing) of red blood cells within the biopolitical landscape of contemporary blood economies. Claims that cultured red blood cells have the potential to address unmet social need and shortages in the blood supply are frequently linked to the production of a *universal product* which would be widely available and accessible. We think such a claim underplays the significance of the international context of blood service delivery within both welfarist and privatized profit-driven, or what we call above 'cosmopolitan internationalist' models. Both models utilize scientific and political techniques of biosecuritization and immunization. What we have argued here is that, despite this, the distinction between welfarist and non-welfarist models is still salient, especially when considering the stem cell source for cultured red blood cells. In our assessment of the concerns raised that 'synthetic' blood could undermine naturalized forms of kinship we concluded that so-called blood gift economies in the UK draw on

ambiguous notions of community and civic solidarity which are exclusionary and reaffirm the fetishized bonds of blood and nation. Representations of cultured red blood cells as 'extending the gift' draw on these ideas of community and civic solidarity. It remains the political and institutional context of the introduction of the technology that matters most here.

Moreover, we suggested that it is not the material separation of blood cells from the body which necessarily leads to alienation but rather whether the proper function of a person is denied by institutional arrangements. Neither do we see the key distinction to be between natural vs synthetic blood. In our analysis, the central questions are what kind of immuno-politics are enacted by the introduction of cultured red blood cells into contemporary blood economies as a form of biosecuritization and what kinds of immuno-politics are materialized by practices of culturing red blood cells? The production of cultured red blood cells within the institutionalist context of welfarist public health systems may serve to prop up a normative public/private distinction, wherein the public utilizes, not unproblematically, discourses of solidarity and 'extending the gift'. But the source material, adult stem cells or cord-blood cells, is relevant to any eventual normative analysis of the institutional context of cultured red blood cell production and utilization. It is, however, not the only relevant factor; participation in blood donation programmes is low in the UK (as elsewhere) and recruitment of cord-blood donors targets ethnic groups in limited geographical areas. Target populations for the testing and use of cultured red blood cells are those with inherited blood disorders such as sickle cell disease and thalassaemia, the very groups who are under-represented in the donor pool. Recruitment of, and uptake by these target groups is likely to be shaped by existing social and health inequalities. Or, to put it another way, cultured red blood cell production, even within the institutional context of NHS Blood and Transfer service, may still materialize a form of cosmopolitan immuno-politics through the construction of 'unmet needs' of those whose haematological profile and health status 'naturalizes' racial and ethnic divisions within an immunitary bioeconomy. In short, the production of cultured red blood cells and their movement through the blood economy and translation to the clinic is unlikely to constitute a revolution.

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Notes

1. Thanks to Ash Toye, Deputy Director of the Bristol Blood & Transplant Research Unit for this. http://bristol.ac.uk/btru/.
2. See: http://www.redcrossblood.org/learn-about-blood/blood-facts-and-statistics and http://www.blood.co.uk/giving-blood/ (accessed 20 October 2015).
3. See: https://aic.mhra.gov.uk/mda/sabresystem.nsf/Login?%20Open (accessed October 2015).
4. See: http://www.fda.gov/BiologicsBloodVaccines/BloodBloodProducts/
5. See: http://novosang.co.uk/media/wellcome-trust-funds-research-cultivate-red-blood-cells (accessed March 2016).
6. For a lay description of thalassaemia, see: http://www.thalassemia.org/learn-about-thalassemia/about-thalassemia/ screening in the UK http://sct.screening.nhs.uk/statistics (accessed June 2015).
7. See: http://novosang.co.uk/media/wellcome-trust-funds-research-cultivate-red-blood-cells and https://wellcome.ac.uk/press-release/first-volunteers-receive-blood-cultured-stem-cells-2016 (both accessed March 2017).
8. See: http://www.thalassemia.org/learn-about-thalassemia/about-thalassemia/ and http://sicklecellsociety.org/ (accessed July 2015).
9. See: http://www.bristol.ac.uk/btru/ for a description of the RESTORE trial (accessed March 2017).
10. See: http://www.redcrossblood.org/learn-about-blood/history-blood-transfusion or http://www.blood.co.uk/about-blood/history/ (accessed March 2015).
11. See: http://www.hbo2therapeutics.com/products/general.php for details of the current manufacture of Hemapure for human use HBOC-201. The product has not been approved for routine clinical use in the US or Europe (accessed March 2015).
12. See: http://www.perftoran.ru/index.php/en/for-physicians/about-perftoran for details of product licensed in Russia (accessed March 2015)

13. See: http://www.lunduniversity.lu.se/article/sugar-beets-could-become-blood-substitute (accessed March 2015).
14. The NIHR Blood and Transplant Research Unit in Red Blood Cell Products, funded by the National Institute for Health Research (NIHR) is a partnership between the University of Bristol and NHS Blood and Transplant (NHSBT) in collaboration with the University of Warwick, the University of Bath and the University of the West of England. http://www.nihr.ac.uk/funding/blood-and-transplant-research-units and http://www.bristol.ac.uk/btru/ (accessed March 2017).

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